

Temperature Effects on Corrosion of Cr⁶⁺, Cr³⁺, and Non-Cr⁶⁺ Conversion Coatings on AlumiPlate, and AlumiPlate Implementations

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ASETSDDefense, Feb 2011, New Orleans, LA



Report Documentation Page			<i>Form Approved OMB No. 0704-0188</i>		
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1. REPORT DATE 14 FEB 2011	2. REPORT TYPE	3. DATES COVERED 00-00-2011 to 00-00-2011			
4. TITLE AND SUBTITLE Temperature Effects on Corrosion of Cr6+, Cr3+, and Non-Cr6+ Conversion Coatings on AlumiPlate, and AlumiPlate Implementations		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AlumiPlate Incorporated, 8960 Springbrook Dr Nw Ste 105 ,Coon Rapids,MN,55433		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES ASETSDefense 2011: Sustainable Surface Engineering for Aerospace and Defense Workshop, February 7 - 10, 2011, New Orleans, LA. Sponsored by SERDP/ESTCP.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 22	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

AlumiPlate® Electrodeposited Aluminum

- Minneapolis, MN, USA
 - Established 1995
 - Technology developed, tested, qualified & implemented
 - 100% RoHS / REACH Compliant
- Electrodeposited Aluminum Corrosion Protection Coating
 - “Green” environmentally friendly replacement for toxic cadmium (Cd) plating (point of app, fly away, MRO)
 - Higher performance than present HAZMAT (Cd, Zn, Ni) corrosion protection technologies and any alternatives
- Well Established Specifications
 - MIL-DTL-83488 & Program / Application Specific



Temperature Effects on Corrosion of Cr⁶⁺, Cr³⁺, and Non-Cr⁶⁺ Conversion Coatings on AlumiPlate, and AlumiPlate Implementations

■ Test Conditions

- Aluminum electroplate per MIL-DTL-83488, Class 2 (0.0005"/12.5 μ min. thk.) on 4130 steel 3" x 6" coupons
- Conversion coat with Cr⁶⁺, Cr³⁺, non Cr⁶⁺
 - Baseline = NO conv. coat,
 - 1 type – Cr⁶⁺ (commercially available)
 - 3 types -- Cr³⁺ (commercially available)
 - 3 formulations – CFP non Cr⁶⁺ -> (provided by NAVAIR under CRADA)
- Temperature exposure: 30C, 250C, 350C
- Corrosion test per ASTM B117

■ Protocol

- 24 hour bake cycle for temperature exposure
- Results are averaged across multiple B117 test runs

- **Test Setup – ASTM B117 Salt Fog Test chamber**



■ ASTM B117 – Definition of Failure



A4 – 30C Cr⁶⁺
4032 hrs

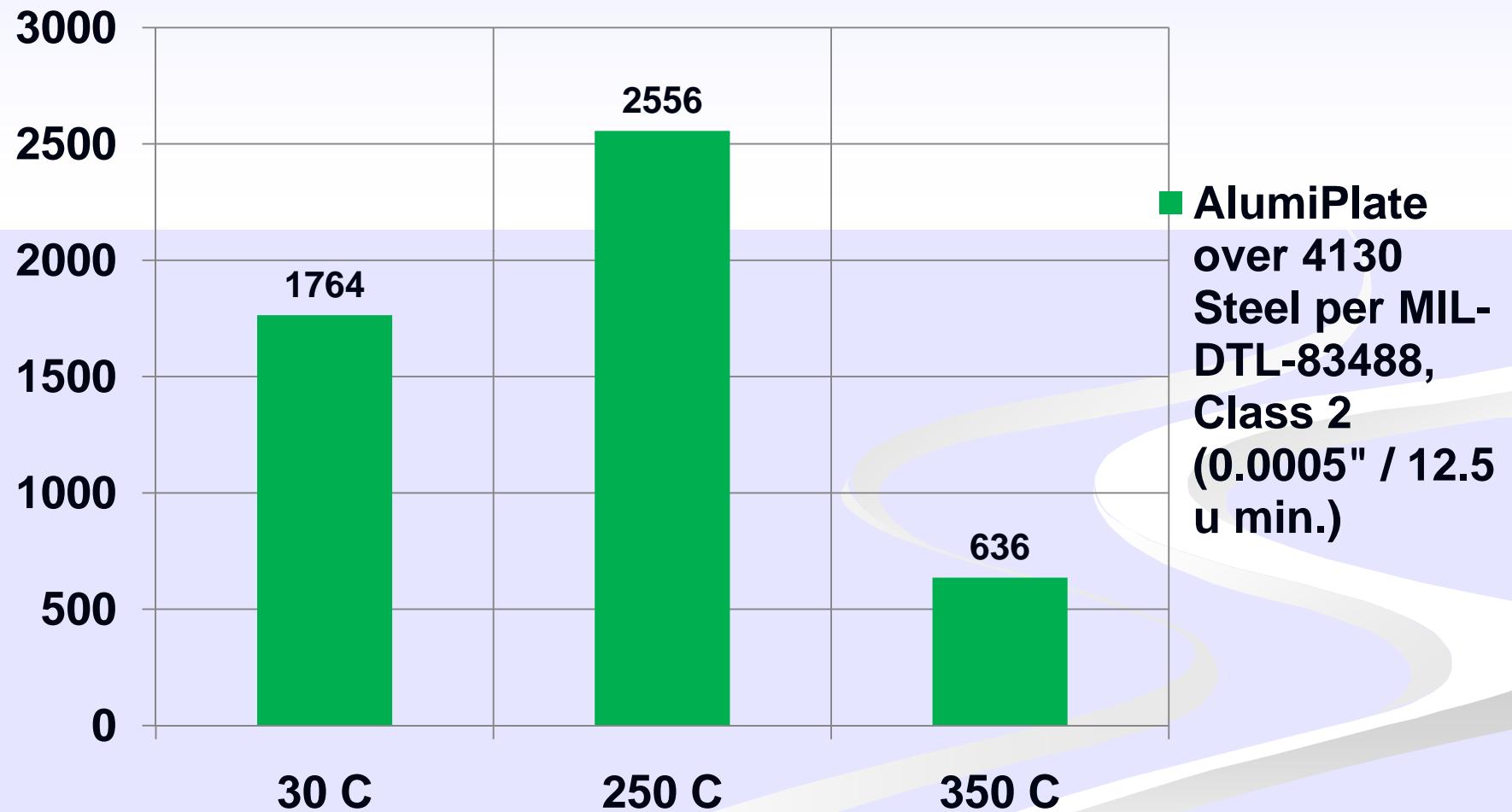


C6 – 250C Cr³⁺
3456 hrs

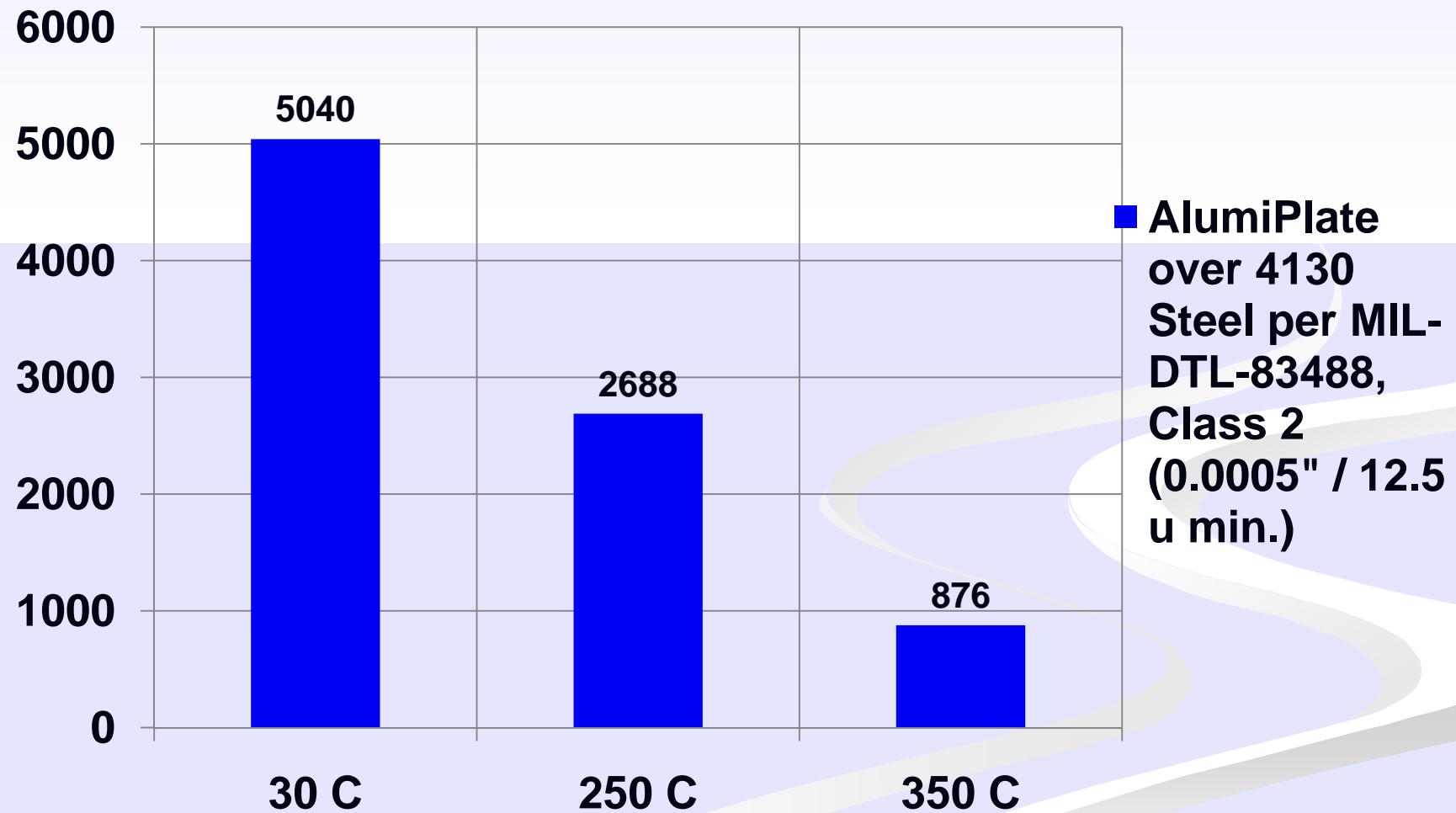


D6 – 350C Cr³⁺
1344 hrs

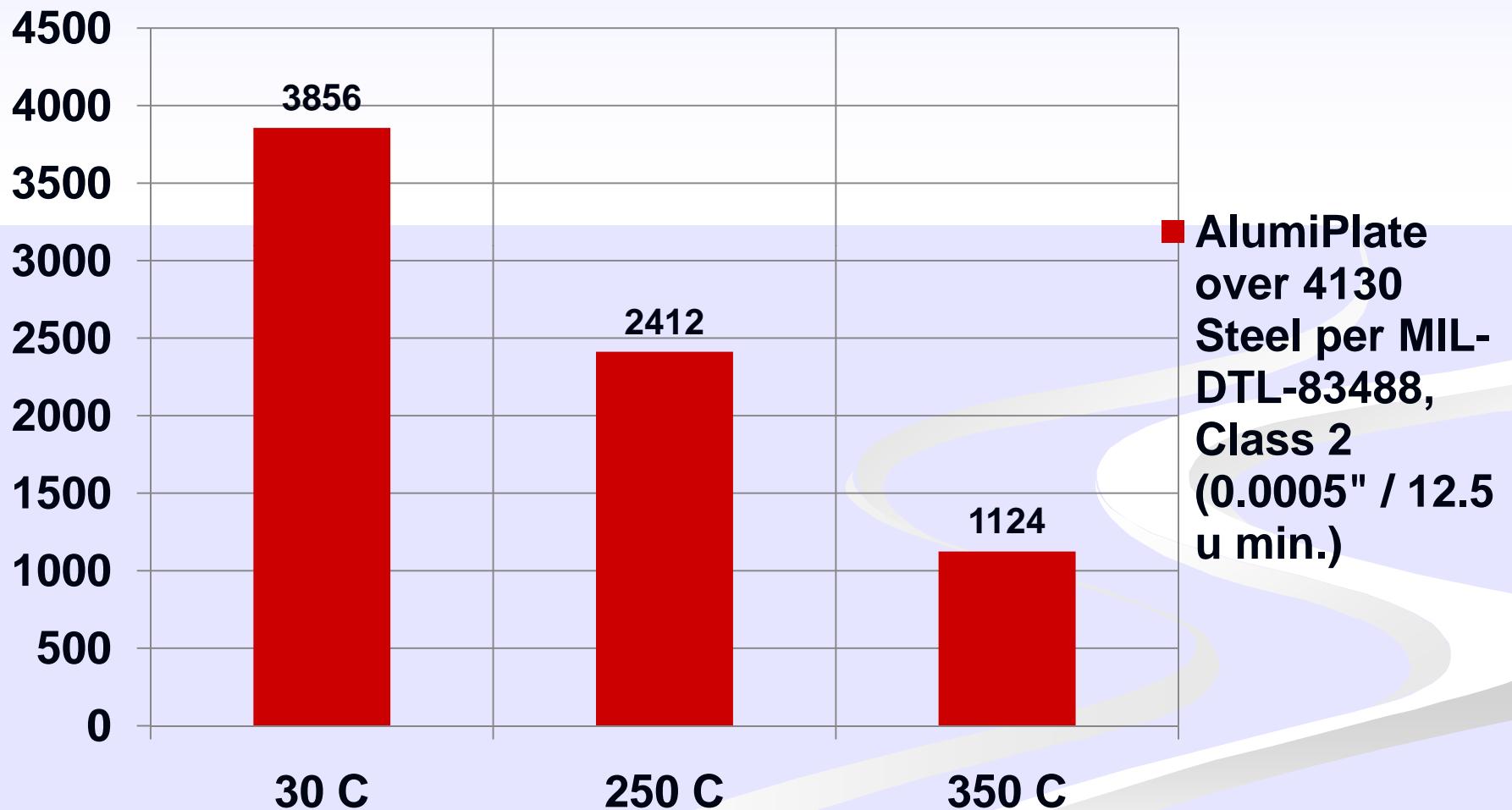
Baseline = No Conversion Coat
ASTM B117 Hours to Red Rust



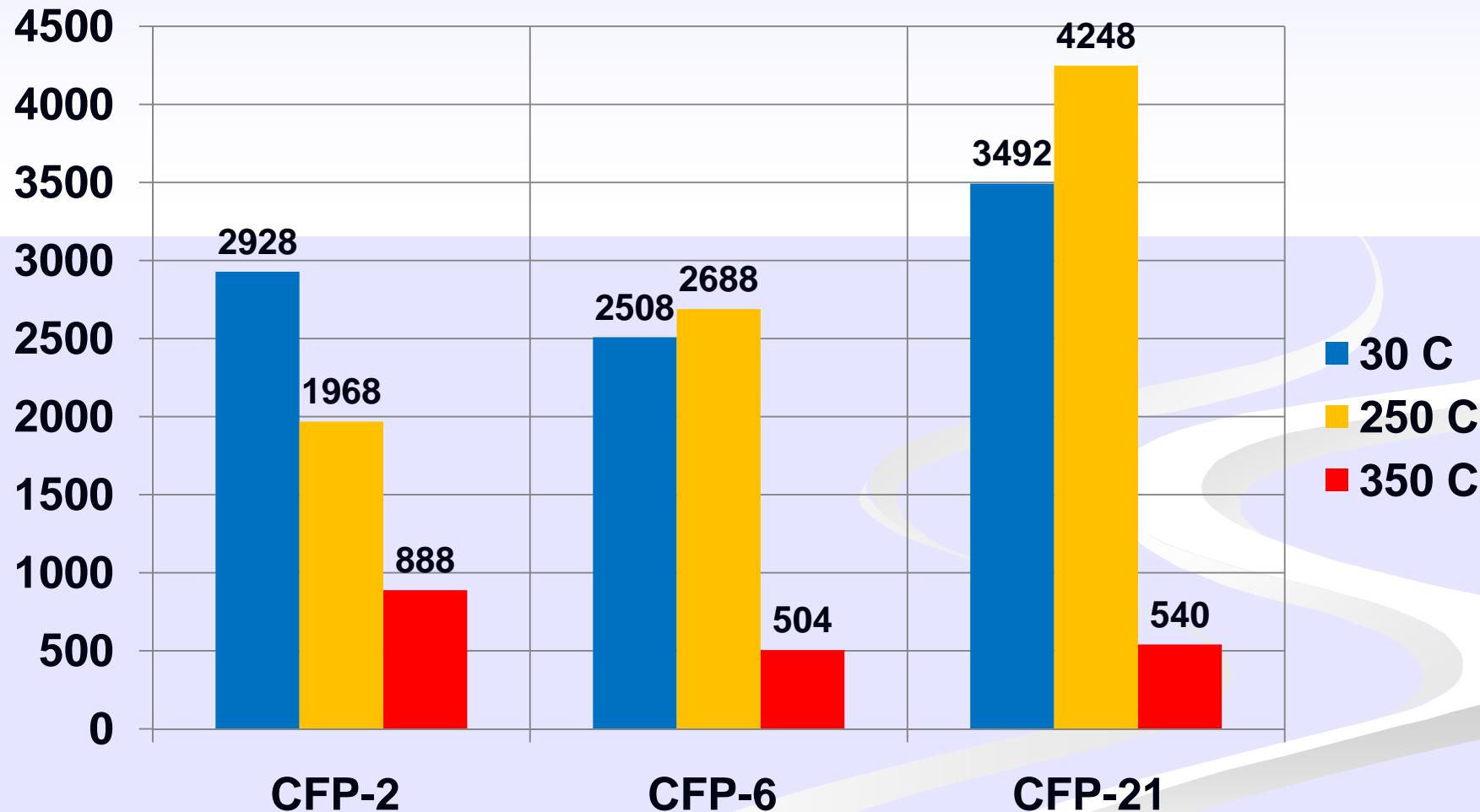
Cr⁶⁺ Conversion Coat **ASTM B117 Hours to Red Rust**



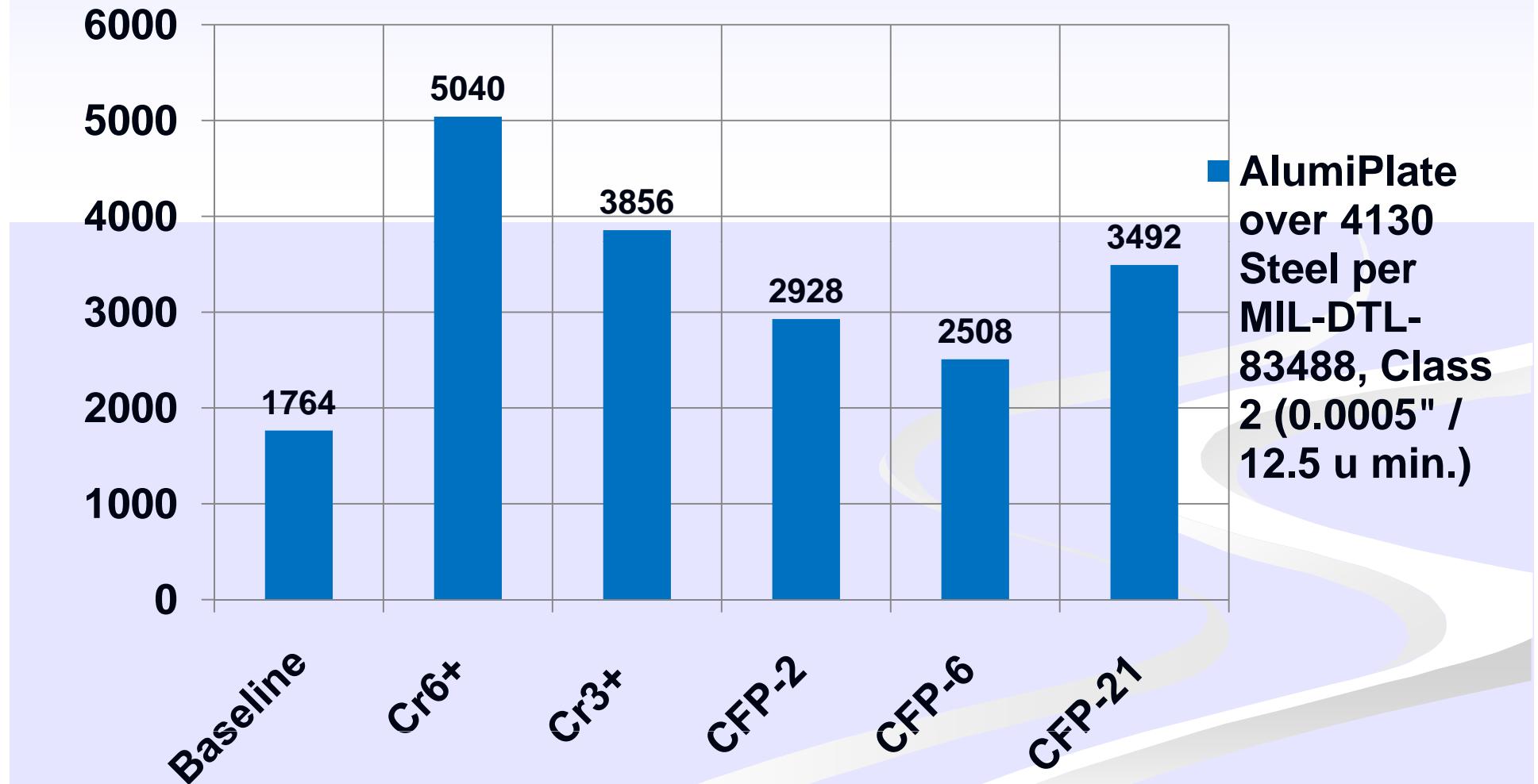
Cr³⁺ Conversion Coat ASTM B117 Hours to Red Rust



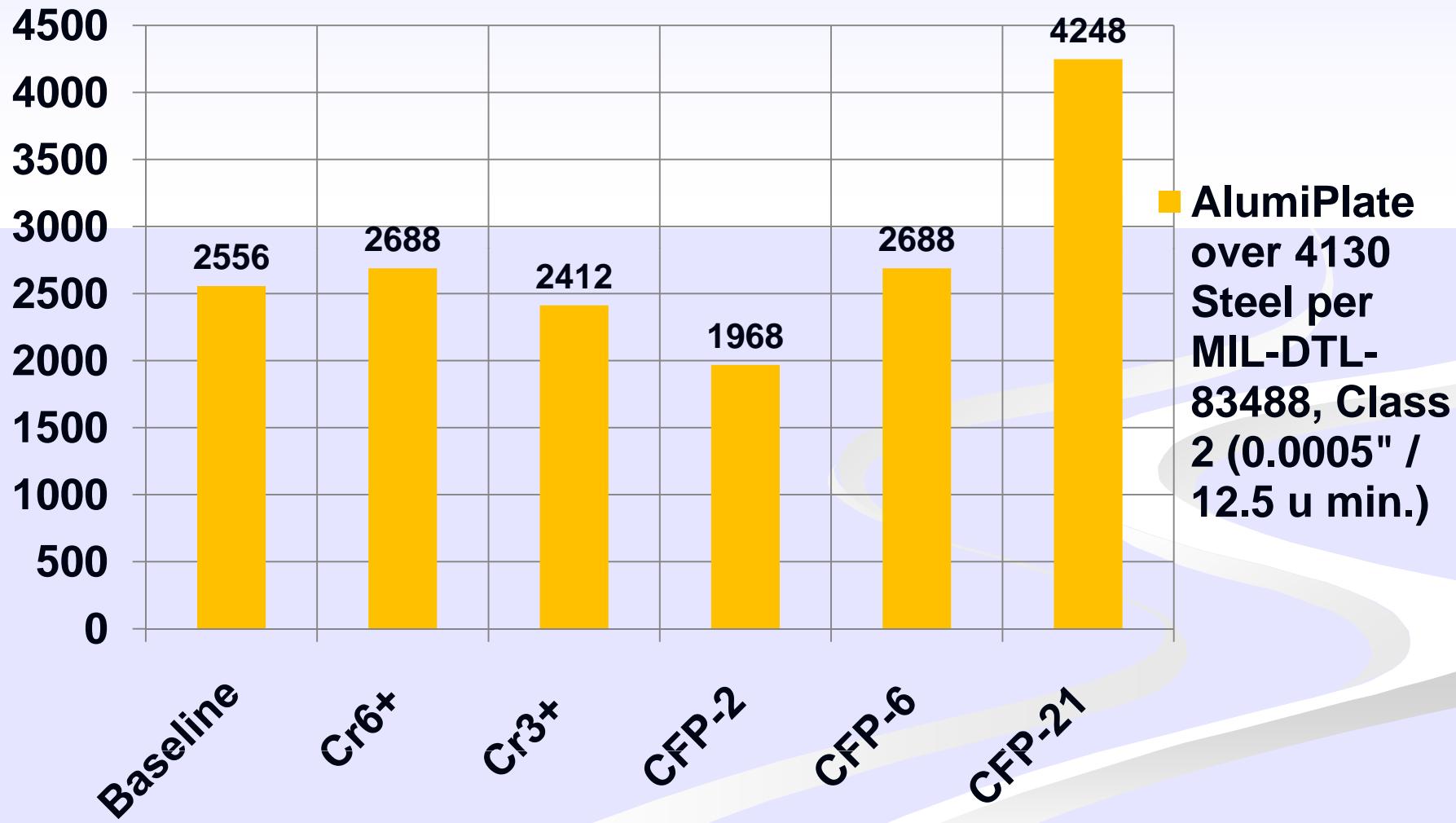
Non-Cr⁶⁺ Conversion Coat ASTM B117 Hours to Red Rust



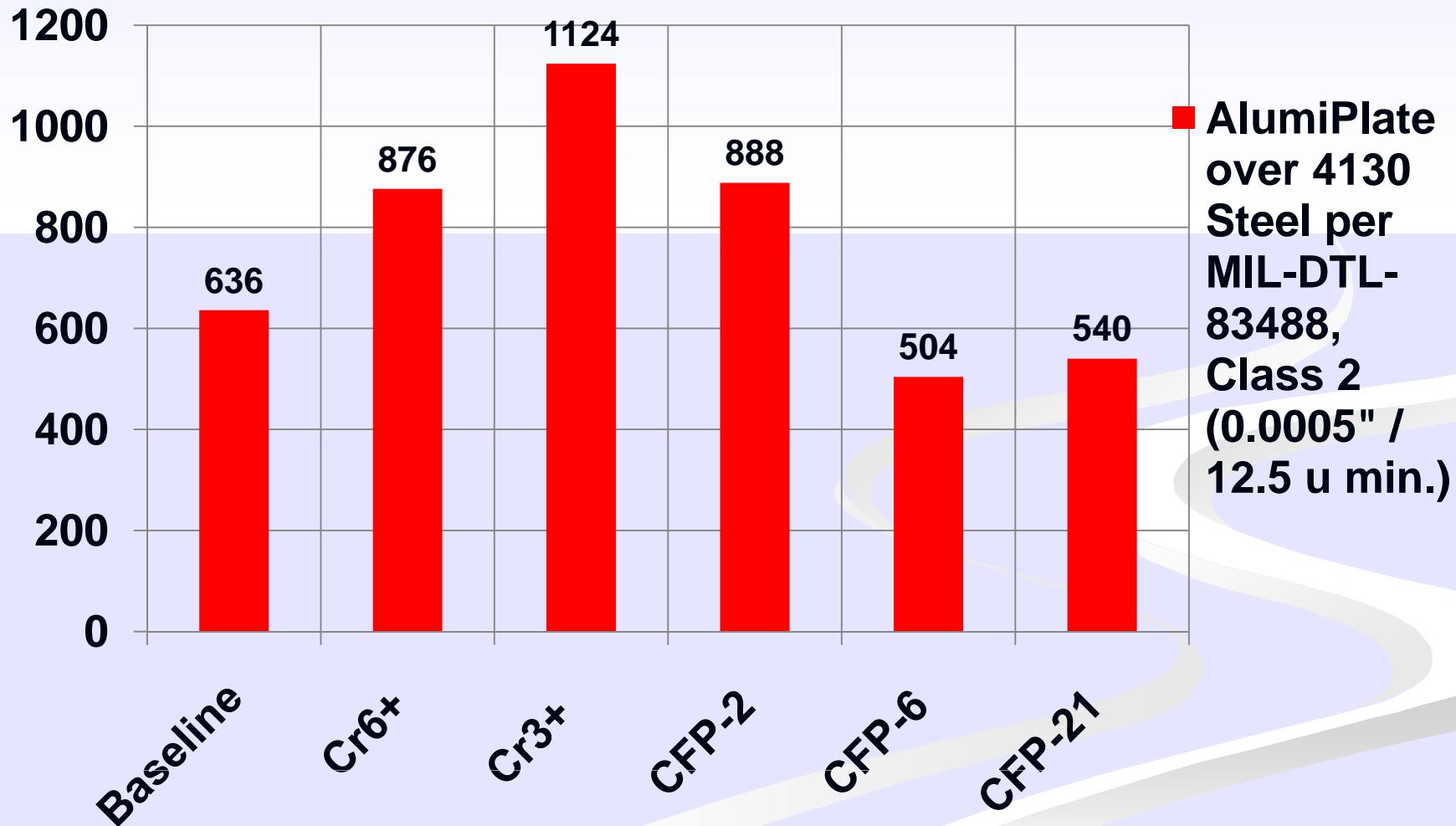
All Conversion Coats at 30 C ASTM B117 Hours to Red Rust



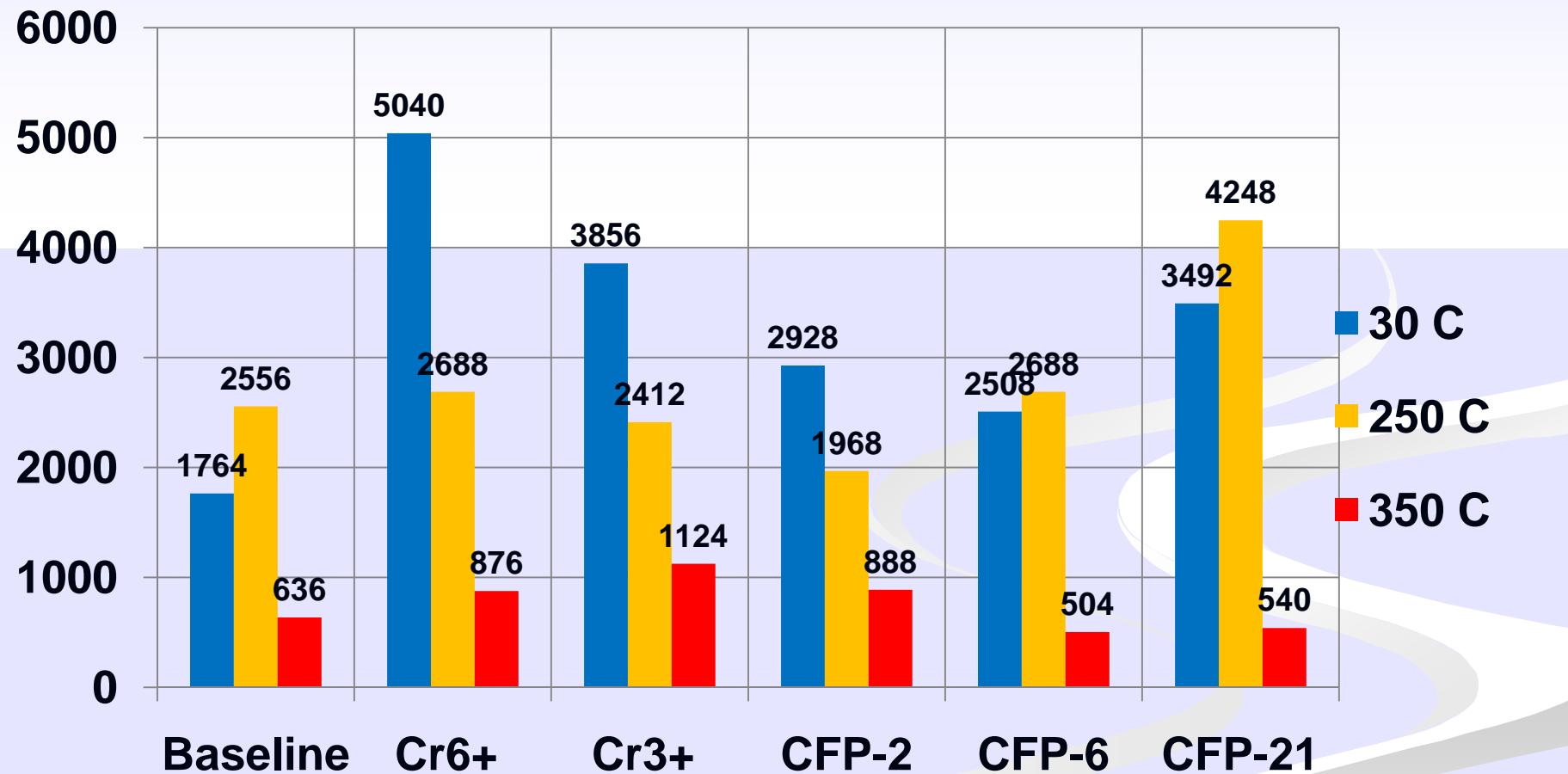
All Conversion Coats at **250 C**
ASTM B117 **Hours** to Red Rust



All Conversion Coats at 350 C - ASTM B117 Hours to Red Rust



All Conversion Coats at All 3 Temperatures ASTM B117 Hours to Red Rust



Conversion Coat & Temperature Performance Summary

In general, across the conversion coatings tested, corrosion performance decreases as temperature increases (new non-Cr⁶⁺ CFP generally better)

Cr³⁺ & non-Cr⁶⁺ CFP provide equivalent or better high temperature corrosion protection compared to Cr⁶⁺

The non-Cr⁶⁺ CFP formulations show promising high temp corrosion protection when compared to Cr³⁺ (WIP)

Status Update - Recent AlumiPlate Implementations on Present Programs

PROGRAM

B-2 Spirit

BHT 4 Series Model 429

M119A Howitzer

RQ-4 Global Hawk

CH53K Super Stallion

(Landing Gear)

PROGRAM

F-16 Fighting Falcon

F-18 Hornet

F-22 Raptor

C-5 Galaxy

F-35 Lightning II

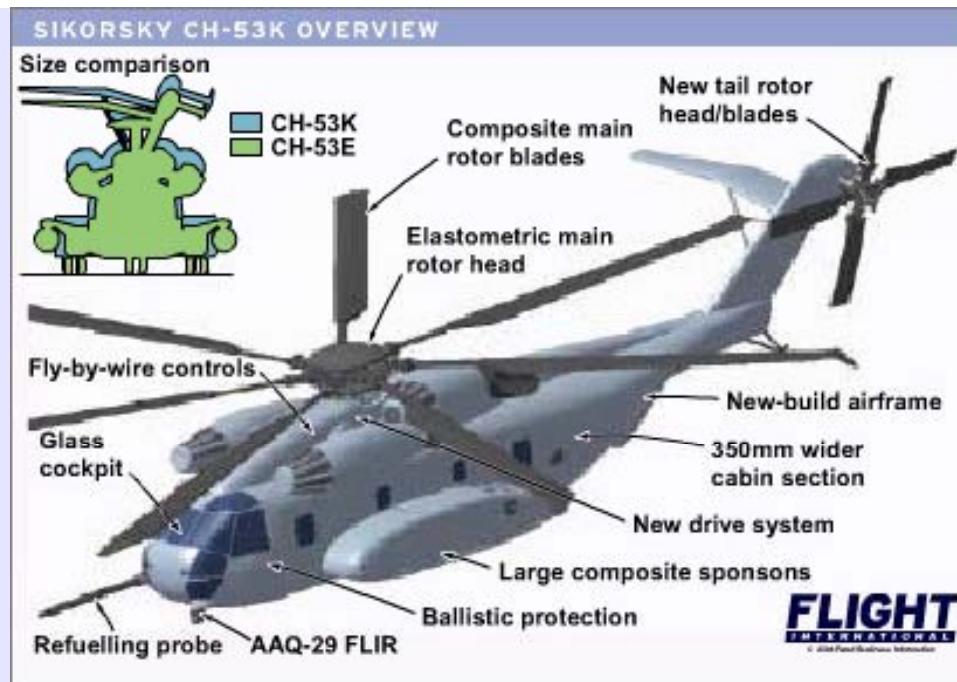
Joint Strike Fighter

(Landing Gear, LEFAS, Elec. Conn.)

US Army Initiative – High Purity Electrodeposited Aluminum to Replace Cd on Fasteners & Electrical Connectors

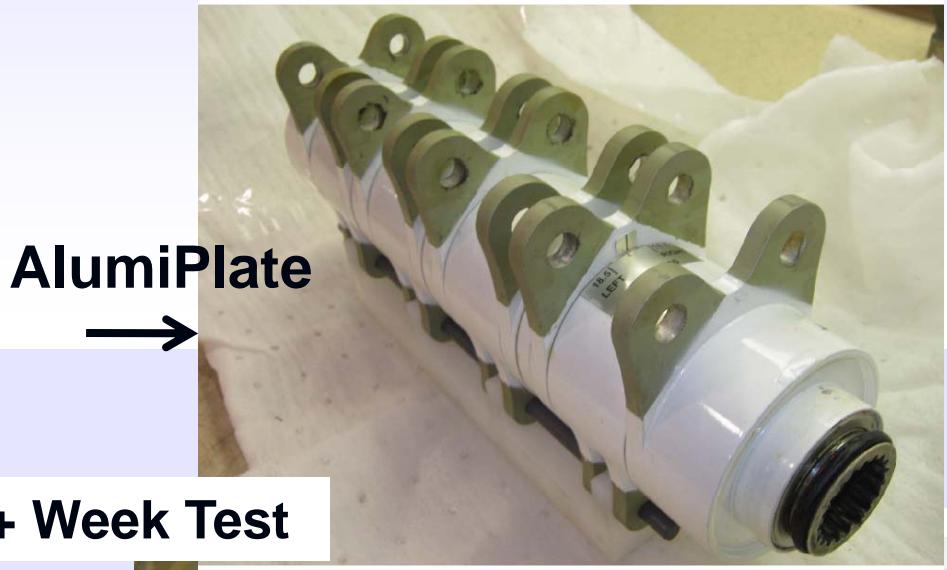
Recent Applications – CH53K – Landing Gear

Images of AlumiPlate coated CH53K landing gear not shown for ITAR reasons. Please contact AlumiPlate for details.





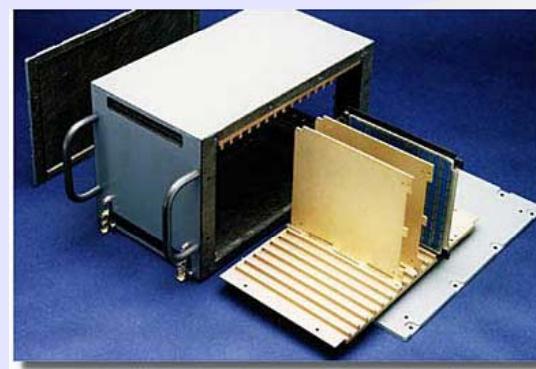
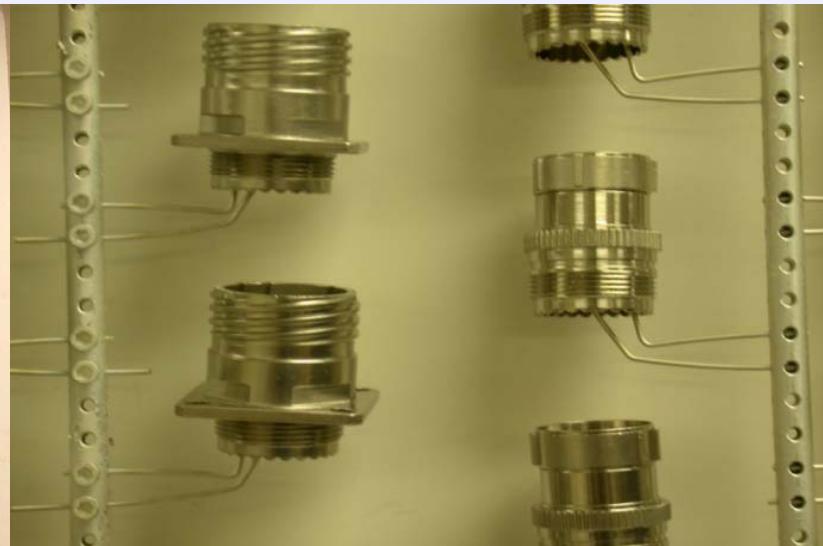
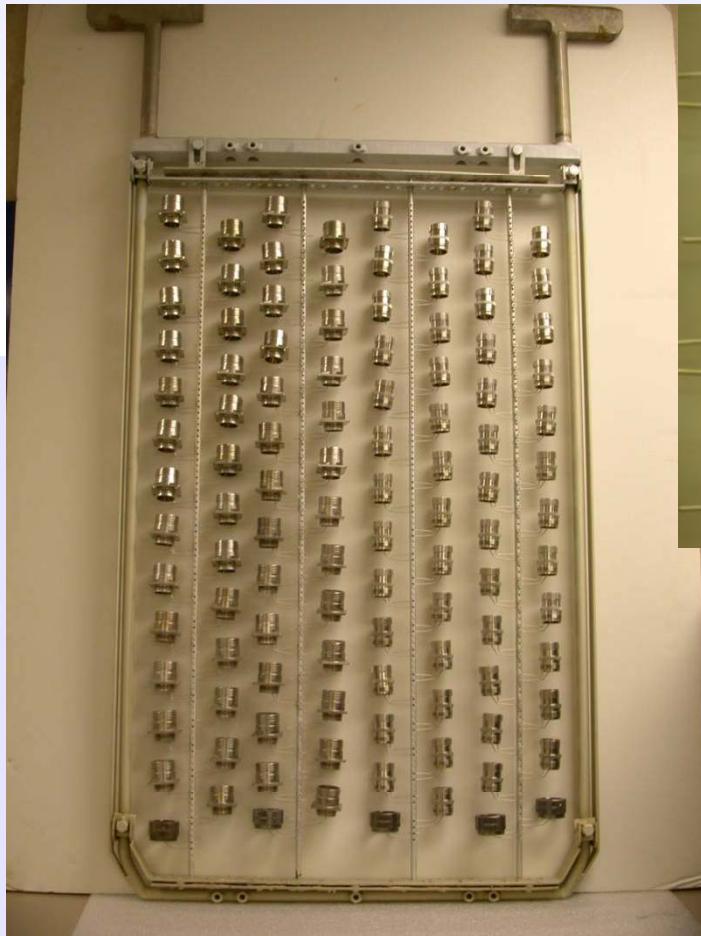
F-35 LEFAS Environmental Qual Tests (in order): Rain (2hr), Icing (168hr), Humidity (250hr), SO₂ Salt Fog (336hr), & Sand & Dust (9hr)



After 4+ Week Test



Recent Applications – Elec Conn



**LMA PH010
MIL-DTL-83488**

**AlumiPlate finish on selected F-35 JSF
electronic components (Honeywell TMC)**

Recent Applications – Elec Conn

ELECTRICAL CONNECTOR SPECIFICATIONS

Electrical Connector Specifications that include “Class P” for Pure
Dense Electrodeposited Aluminum as a Cadmium Alternative

MIL-DTL-24308G
MIL-DTL-38999
MIL-DTL-83723

MIL-DTL-32139A
MIL-DTL-28840
MIL-DTL-22992G
AS85049

MIL-DTL-83513G
MIL-DTL-26482
MIL-DTL-3607C

Recent Applications – Fasteners



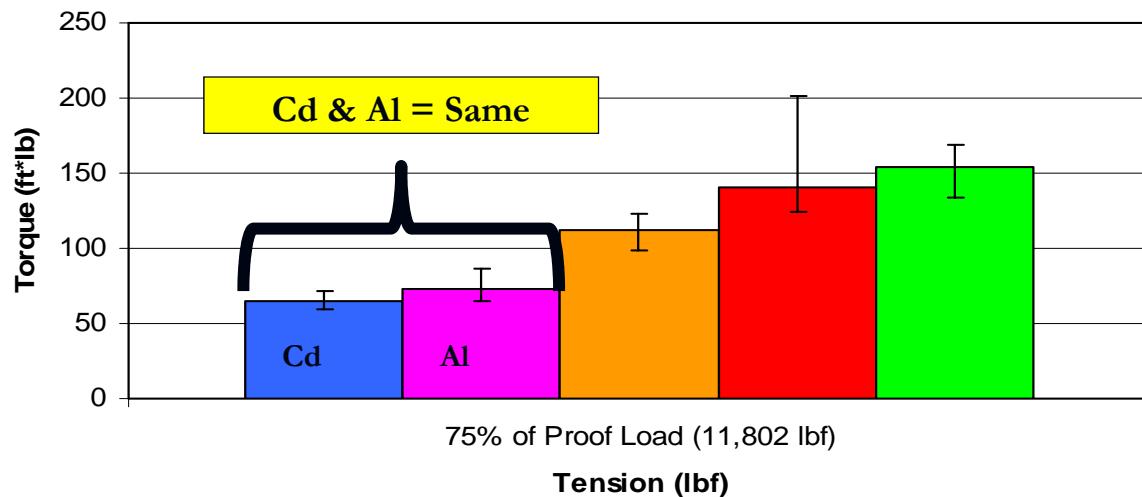
STRYKER Wheel Bolts – Field Trial

Zn Plate
with Cr⁶⁺
+ CARC
Topcoat
←

→ AlumiPlate
with Cr³⁺
NO
Topcoat



Torque-Tension @ 75% Proof Load



- Cadmium w/ 30 Weight Oil (K=.14)
- Aluminum w/ Everlube 9002 (K=.16)
- Cadmium - Dry (K=.24)
- Aluminum w/ Magni B18 Silver (K=.30)
- Aluminum w/ 30 Weight Oil (K=.33)

Grade 10.9
M12 x 50mm
All from same heat lot
30 samples each test condition
T n T & GM9540P & etc.

Electrodeposited Aluminum

Performance Status

- **Proven performance vs. Cd Cr⁶⁺**
 - (CH₃CO₂K ground runway deicers)
- **High temperature performance with Cr³⁺ & non-Cr⁶⁺**
- **Potential lower lifetime costs (lower corrosion costs)**
- **ESOH Friendly (at point of application & coating on product)**
- **Commercially available (TRL 7+, MRL 8)**

Implementation Status

- **Slow but steady adoption program by program (part by part)**
- **Supply chain availability a challenge but being addressed thru DPA Title III Project Request working with a S.E. Michigan metal finishing company partner**
 - New large capacity plating line targeted for late 2012

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